POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Optimization methods in design [S2Elmob1>MOwP]

Course

Field of study
Electromobility

Year/Semester
1/1

Area of study (specialization)
–

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
15

Number of credit points

2,00

Coordinators

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Lecturers

Prerequisites

The student starting this subject should have basic knowledge of mathematical analysis, linear algebra and vectorial calculus. He should also have the ability to formulate a design task at the engineering level and the ability to computer programming at the general level. The ability of effective self-education is required by obtaining information from indicated sources and the awareness of the need to expand their competences and readiness to cooperate within a team.

Course objective

Acquiring the skills to correctly formulate a synthesis task of technical devices and to optimize such devices. Getting knowledge about deterministic and non-deterministic methods of unconstrained optimization. Acquiring knowledge about methods of considering the technical and economical constraints. Student should gain the ability the identification and formulate tasks of multi-criteria optimization. He should also acquire the ability of the selection of the algorithm of the optimization to the solved the put problem.

Course-related learning outcomes

Knowledge:
1. Has an expanded and in-depth knowledge of selected areas of mathematics necessary to describe the

elements, systems and systems used in electromobility [K2_W01].
2. Student has in-depth and structured knowledge in the field of analysis and synthesis of circuits and low- and high-voltage installations of hybrid and electric vehicles, including traction [K2_W02].
3. Student has in-depth knowledge of magnetic and insulating materials, as well as coupled phenomena in systems with electric, magnetic and thermal fields [K2_W05].
4. The student has knowledge in the field of computer analysis and synthesis of electromagnetic devices, including the use of deterministic and heuristic optimization methods; knows the principles of prototyping electromagnetic devices using Cax tools [K2_W06].

Skills:
1. Student can use the knowledge of the latest technical and technological achievements in the design of non-standard devices and systems in the field of electromobility [K2_U01].
2. The student is able to formulate and test hypotheses related to complex engineering problems and simple research problems in the field of electromobility, as well as interpret the obtained results and draw critical conclusions [K2_U04].
3. The student is able to determine the functionality and designing systems and systems of electric vehicles, apply adequate analytical, simulation and experimental methods, assess their usefulness and limitations in advance, and adapt them to the specificity of the problem or the need to take into account unpredictable operating conditions [K2_U06].
4. The student is able to formulate and solve engineering tasks, take into account unpredictable conditions, given technical specifications and non-technical criteria, ensuring savings of raw materials and energy and security of IT systems of electric vehicles [K2_U11].

Social competences:
1. Student is aware of the importance of the latest scientific and technical achievements in solving research and practical problems and, if necessary, supporting expert opinions [K2_K02].

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture:
- assessment of knowledge and skills demonstrated in the written exam of a problem nature,
- continuous assessment during each class (rewarding activity and quality of perception).
Project:
- checking and rewarding knowledge necessary to implement the problems raised,
- evaluation based on the current progress of project implementation in the form of computer programs.
Achieving extra points for activity during classes, especially for:
- proposing to discuss additional aspects of the analyzed problem;
- effectiveness of applying the acquired knowledge during solving a given problem;
- comments related to the improvement of teaching materials.

Programme content

The program includes formulating of the optimizing task of technical object and presents the principles of operation of selected deterministic and non-deterministic optimization methods.

Course topics

Analysis and synthesis of the electromagnetic devices. Formulation of the optimization task of a technical object: design variables, objective function and constraint functions. Normalization of variables and functions. Deterministic optimization methods. Gradient-free methods: Hooke-Jeevs method and Rosenbrock method. Gradient methods: fastest descent method and conjugate gradient method. Directional minimization. Non-deterministic (heuristic) methods: genetic algorithms, particle swarm method, bat algorithm, grey wolf method, cuckoo search algorithm, salp swarm algorithm. Optimization with equality constraints: the Courant method. Optimization methods with inequality constraints: external penalty function, barrier functions and static penalty function. Multi-criteria optimization.

Teaching methods

Lecture:

- lecture with multimedia presentation supplemented with examples given on the board,
- lecture conducted interactively with the formulation of questions to a group of students and taking into account the activity of students during classes when issuing the final grade,
- discussion of various aspects of solved problems, including economic, ecological, legal, social.

Project:
analysis of different methods to solve the problem,
- developing and implementing an effective computer program to optimize the selected technical object,
- multimedia presentation.

Bibliography

Basic:
1. Swarm intelligence, J. Kennedy, R. C. Eberhart, Y. Shi, Elsevier Science, 2001.
2. Nature-Inspired Optimization Algorithms, Xin-She Yang, 2nd Edition, Elsevier, 2020.
3. Handbook of Metaheuristic Algorithms, Chun-Wei Tsai, Ming-Chao Chiang, ACADEMIC PR INC, 2023.
4. Optymalizacja, Wybrane metody z przykładami zastosowań, J. Kusiak, A. Danielewska-Tułecka, P. Oprocha, PWN, Warszawa 2009.
5. Podstawy metod optymalizacji, K. Amborski, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2009.
6. Algorytmy genetyczne i ich zastosowania, D.E. Goldberg, WNT Warszawa, 1998.
7. Optymalizacja i polioptymalizacja w mechatronice. Wojciech Tarnowski, Wydawnictwo Uczelniane Politechniki Koszlińskiej, Koszalin 2009.

Additional:
1. Multiobjective shape design in electricitry and magnetism, Paolo Di Barba, Lecture notes in electrical Engineering, Springer, 2017.
2. Genetic algorithms in search, optimization and machine learning, Goldberg E.D., Addison Wesley Publishing Company, Inc., 1989
3. Minimization of Torque Ripple in the Brushless DC Motor Using Constrained Cuckoo Search Algorithm, Ł. Knypiński, S. Kuroczycki, F. P. G. Marquez, Electronics, vol. 10, no. 18, s. 2299-1-2299-20, 2021.
4. Optimization of the rotor geometry of line-start permanent magnet synchronous motor by the use of particle swarm algorithm, Knypiński Ł., Nowak L., Jędryczka C., COMPEL - The International Journal For Comp, 2014.
5. Optimal design of the rotor geometry of line-start permanent magnet synchronous motor using the bat algorithm, Ł. Knypiński, Open Physics, vol. 15, no. 1, 2017, pp. 965-970.
6. Constrained optimization of line-start PM motor based on the gray wolf optimizer, Ł. Knypiński, Eksploatacja i Niezawodność - Maintenance and Reliability, vol. 23, no. 1, pp. 1-10, 2021.
7. Constrained optimization of the brushless DC motor using the salp swarm algorithm, Ł Knypiński, R, Devarapalli, Y. Le Menach, Archives of Electrical Engineering, vol. 71, no. 3, pp. 775 - 787, 2022.
8. Parameter Extraction of Solar Photovoltaic Modules Using a Novel Bio-Inspired Swarm Intelligence Optimisation Algorithm, R. Ishwar Vais, K. Sahay, T. Chiranjeevi, R. Devarapalli, Ł. Knypiński, Sustainability , vol. 15, iss. 10, s. 8407-1-8407-27, 2023.

Breakdown of average student's workload

	Hours	ECTS
Total workload	55	2,00
Classes requiring direct contact with the teacher	30	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	25	1,00